## SECTION 4

## GRADE CONTROL, SCREEDS AND BULKHEADS

### 4-l COMPUTATIONS

#### 4-1.1 4-SCALE CONTOURS

We refer to bridge deck contour plots that are drawn to a scale of 1 inch equaling 4 feet as '4-scales'. In most cases 4-scale contour plots are available from Bridge Design in Sacramento. Bridge Construction Memo 2-4.0 outlines the procedure to be used for obtaining the 4-scale contour plots. (See Appendix 4).

After receiving the 4-scale contours, a detailed check of the plan dimensions and grades is required and any detail errors and conflicting dimensions must be corrected before making copies of the deck contour plots available to the Contractor. Each bridge 4-scale sheet should be checked against the final finish grade profiles and the superelevation diagrams shown in the grid grade book. Also, edge of deck profiles should be drawn in order to check for dips or humps caused by superelevation transitions, alignment tapers, and other anomalies. This profile should extend beyond the bridge paving notches and include retaining walls, wingwalls, and bridge approach rail as well as a section of roadway. Sections of the 4-scale may require revision in order to avoid possible grade problems.

## 4-1.2 PROFILES

### 4-1.2.1 WIDENINGS

Typically, widened decks are constructed to match both an existing bridge deck as well as theoretical grades generated for the outside edge of the widened deck. Some features of existing decks which may cause problems are:

(1) too much camber;

(2) too little camber;

(3) bumps not corrected on the original contract;

(4) rough surfaces and other defects under removed curbs and rails.

Existing decks may require grinding or overlays to correct these problems.

Sometimes medians are widened so that the top deck must match two existing bridge decks., in lieu of one, and also a theoretical centerline profile. This type of widening may provide situations where the existing bridge deck profiles are in conflict with each other as well as with the theoretical centerline profile. In order to satisfy this condition, the profiles will need to be adjusted, the deck cross slopes may need to be varied, or other solutions sought. It should be noted that closure pours between new left and right structures pose similar challenges.

Edge profiles for the existing decks and roadways are sometimes included in the contract plans. These should be re-shot and checked. Profiles should be developed as early as

possible in order to determine if remedial work is necessary. It is important that grade problems are identified and solutions planned early in construction.

#### 4-1.2.2 NEW CONSTRUCTION

On long ramp structures, viaducts, and any structure requiring multiple pours, potential bump problems exist at each transverse bulkhead, expansion joint or hinge. With proper profiling and grade control of the adjacent work, the edge of deck grades can be constructed without grade or slope discontinuities.

Extra effort is required when a second deck pour must "come into" or match an existing deck at a hinge or a transverse construction joint. It should be recognized that care at the end of the first-pour is essential in obtaining a satisfactory joint. It is much easier to match something that is right than to try and compensate for irregularities. After the first deck pour, the deck should be cross sectioned and profiled. A grid of points, preferably at even stations and offsets, should be established on the first day after the pour. Elevations should be shot at this time and monitored until grades are established for the second deck pour. These elevation points are used to check for the possibility of long-term falsework settlement as well as monitoring any movement of prestress hinges. In a few cases, soffit grades as well as "lost deck" and screed grades will require adjustment. Profiles of the first deck should be

extended onto the second deck profiles and compared with theoretical values. Adjustments, if any, are then made to the second deck pour grades.

It is very important to maintain exact stationing and bench datum on steeply cross sloped decks, or decks with sharp vertical curves or with steep profile grades. The Engineer should mark stationing in the newly finished edge of deck or develop some other method to assure correct stationing for the next segment. Edge of deck points should also be laid out and shot the first day after the pour.

## 4-1.3 DEAD LOAD DEFLECTION; CAMBER AND SETTLEMENT

Camber for the decks of conventionally reinforced concrete box girder, T-beam and slab bridges is the algebraic summation of the anticipated long term deflection due to creep of the concrete and the initial dead load deflection. Experience has -shown that for box girder and T-beam structures, essentially all of the falsework deflection occurs when the girders are poured. This is true even for post tensioned bridges with long falsework spans. (Studies indicate that for a post tensioned box girder bridge, 50% or less of the theoretical deflection due to the deck slab dead load is realized when the deck is poured.) Therefore, the deck camber for conventional reinforced or prestressed box girder and T-beam structures would normally not include falsework deflection.

**Deck camber for prestressed "I" girder bridges is dependent on the time that has elapsed between stressing the girders and placing the deck. Because a significant portion of the dead load is not applied to the girders until the deck is placed, the prestressed "I" girders tend to creep upwards. In order to try and compensate for this upward movement of the girders, Bridge Design has started including camber values based on an anticipated elapsed time between stressing girders and placing the deck (see Appendix 4). The designer should be notified and the camber diagrams modified if this anticipated elapsed time is going to be changed.**

**Deck camber for steel girder bridges would include the initial deflection of the girder(s) due to the dead load of the deck, do not include the deflection caused by the weight of the girder(s). Plus in the case of composite design, a residual amount to compensate for the additional deflection due to shrinkage of the slab.**

**The residual camber shown on the plans for concrete structures should be examined and unreasonable amounts questioned.**

**Long term deflection of conventionally reinforced concrete bridges continues over a period of about 4 years. Approximately 25% of the total deflection is realized immediately after the falsework is removed. The initial deflection as well as the total deflection can be reduced by delaying falsework removal. Consequently, on widenings, the plans or Special Provisions**

**frequently require falsework support for a longer period of time. In order to further reduce the grade differential between widened and existing decks, the specifications may also require that a minimum period of time must elapse between the time the falsework is released and the closure pour is made. (See Appendix 4). Typically, the contract plans show only one camber diagram for each bridge widening. However, after the closure pour is made, the widening is usually restricted from deflecting the same as an independent bridge would. Depending on the amount of camber and the time of the closure pour, the total anticipated deflection for the section of the widening located next to the existing bridge may never be realized. Therefore, the amount of camber for this section of the widening may need to be adjusted in order to reduce possible grade differentials that could develop between the widened and existing decks.**

**As with falsework members, the dead load deflection of steel girder bridges must be checked. Before steel girder fabrication, the effect of built-in camber should be checked using the 4-scale layouts. Deck forms and screeds, for steel girder bridges, are graded by using fills from the girder flanges. These are determined by comparing the profiles of the girders with those of the finished deck, including the anticipated deflection, along the girder line. In connection with steel girder profiles, there are three important things to remember:**

**(1) <u>Safety, do not perform any work of any kind without adequate safety devices</u>, (i.e., a safety belt attached**

to a cable, a safety rail running the length of the girder, safety nets, etc.);

(2) grade points must be accurately laid out and referenced to the center lines of bearing;

(3) level circuits should only be run early in the morning when temperature variation is minimal and while the girder temperature is constant or stable. Do not go back later in the day and attempt to check elevations! These elevations may not even be the same the next morning!

Settlement, insofar as bridge decks are concerned, can occur in the falsework and/or the forming system. Normally bridge deck settlement results from form take-up, assuming that falsework settlement has terminated or has been stabilized. Exceptions would include the following: slab bridges where settlement is compensated for by screed adjustment during concrete placement operations, post tensioned bridges where falsework settlement may occur due to prestressing forces applied after the deck is poured, and deck forming systems such as overhangs designated as falsework.

Falsework settlement is covered in both the Standard Specifications and the Falsework Manual. However, it should be noted that some falsework settlement due to take-up in forms is normal; but, the quality of workmanship must be such "that the falsework will support the loads imposed on it without excessive

settlement or take-up beyond that shown on the falsework drawings."

## 4-1.4 FIELD NOTES

With current staffing levels, an organized and systematic approach towards bridge deck construction is more important than it has ever been in the past. Proper field book entries are essential in order to provide the required bridge deck elevations in an expeditious manner. Entries for box girder deck construction should include the following:

Lost deck elevations - Typically, saw cuts are placed on girder stirrups or on pipes (or rebar) cast in the girder stems so as to provide the Contractor with top deck elevation control points. The Standard Specifications state that "The locations of such elevation control points will not be closer together than approximately 8 feet longitudinally and 24 feet transversely to the centerline of bridge." The spacing of the deck elevation contol points should be close enough to allow the use of a string line to check the deck. Deck elevation control points can be grade marks a constant distance below finished deck grade, grade marks at finished grade, or fills to finished deck grade from preset points.

Normally a small error of closure exists between field measured points and layout scaled dimensions. This is true in soffit grades as well as lost deck grades. If these errors are not adjusted and discrepancies are allowed to accumulate, the

camber diagrams will not be correctly related to the substructure, and wingwall and column grades. will not match the superstructure grades.

One acceptable method for adjusting errors is to assume that bents, piers, and abutments are in the correct location and prorate the error out within the spans. Layout the points on the 4-scale as measured in the field and shrink or expand the scale to make field measurements match the layout. Stations on soffits and soffit grade points should be similarly adjusted.

Overhangs - When the overhang is formed after the girder stem pour, the Contractor should use the lost deck grades to establish grade for the inside potion of the overhang located next to the exterior girder.

Once the locations of the overhang adjustment points can be determined, the overhang grades should be generated. Typically, these grades are taken directly from the edge of deck profiles that were drawn to check the 4-scale contours. Depending on the forming system used, additional camber may need to be added to the overhang grades.

The bench mark used for grading the overhang should always be checked against that used for shooting lost deck grades.

Screeds - Typically, the overhang grades are used to shoot the screed. Depending on the forming system used, additional camber may need to be added to the screed grades to compensate for deflection due to the bidwell.

**Bulkheads** - Finish deck grades at bulkheads and paving notches are established by the finishing equipment.

Note that all grades used for deck construction should be tied together and that grades should always be checked back to previously shot grades for continuity. Lost deck grades should be spot checked when shooting overhang grades to check for long term falsework settlement. Stationing and level datum must be coordinated between adjacent pours in order to provide a matching deck surface. Location and accessibility to bench marks require foresight to prevent the loss of key elevation points.

## 4-2 GRADING AND INSPECTION

### 4-2.1 CONTRACT SURVEYING

Although the use ofcontract surveying has been discontinued/phased out, this was an important part of our operations and will be briefly addressed.

Contract surveying was incorporated into some projects as a way of reducing the amount of staffing needed, and to make the Contractor responsible for providing the line and grade required to complete the job. Bridge construction personnel were expected to perform enough surveying to assure that each structure was being built to the lines and grades specified. Typically, the Structure Representative checked almost all of the Contractor's survey points at the beginning of each job. But as the project progressed, the Structure Representative would adjust the amount

of checking to reflect the level of confidence developed towards the Contractor's Surveyors.

## 4-2.2 LEVELS AND TRANSITS

A systematic schedule for maintaining, cleaning and pegging levels should be established on every project. It should be posted and kept up to date. Instruments can and do get out of adjustment - handle them with care! Check level legs for stability as they can get loose and wobbly at the leg tips and at the connection to the plate. Check lenker rods for loose sole plates and sloppy operation.

## 4-2.2 OVERHANGS

Grading and inspecting the overhang bulkheads and the overhang supports are two of the most important items of deck construction. The contractor's plans should be checked for structural adequacy and details that may result in uneven settlement. Extra attention should be given to connections and bearing areas. All joints must be solid in order to prevent differential deflections due to the weight of the finishing machine. Look for potential stability problems such as a tipping overhang due to loads being concentrated along the outside section of the overhang.

If the overhang is constructed at the same time as the girder stem forms, precautions must be taken to keep the overhang clean. Plastic sheeting, "lost deck" plywood covering, and

**building paper have been used in the past as ways to protect the overhang forms. If the overhang is built after the girder stem pour, check the grade at the exterior girder before the deck reinforcing steel is placed. Always check the overhang lumber for defects as the overhang is being constructed.**

**If overhang jacks are used, make sure that they/are installed per the manufacturer's recommendations. Jacks should not be extended too far, vertical legs and screw adjustments should be plumb, etc. On steel girder bridges the connection to the web should not cause web dimpling and bracing may be required to prevent girder rotation. Check lumber for defects and watch for tipped joists etc.**

**The overhang should always be rough graded before the edge of deck line is established:. Otherwise, the edge of deck line may shift if the overhang grades are adjusted an appreciable amount.**

**The -method and manpower requirements for grading the overhang should be worked out with the contractor in advance. Rodmen and carpenters must be made aware of the importance of form continuity and of the importance of checking back on previously graded points. Sometimes previously graded points change in elevation as the overhang is graded.**

**It is common practice for the contractor to rough grade the overhang approximately 1/2" low. It is then adjusted to final grade as directed by the engineer. It is usually easier and quicker to jack or wedge the overhang up in lieu of trying to**

lower it. Overhang support geometry may cause a grade change at the edge of deck if both the interior and exterior supports are not graded simultaneously. This is usually not a problem if both overhang supports are rough graded before the final grading operation. After grading, the joists should be feather wedged tight and the overhang eyeballed.

## 4-2.4 SCREEDS

Since screeds are normally placed on the overhang, one method for grading the screed is to shoot the screed using the overhang grades and adjust the Lenker rod to compensate for the elevation difference between the overhang and the screed. Another method is for the contractor to grade the screed with a template, or "story pole", set on the graded overhang. Still another method, although it is not generally recommended, is for the Contractor to grade both the overhang and the screed from the deck grades on the exterior girder.

Screeds should be spot checked for adequate support. Screeds for a Bidwell finishing machine should be 2-inch diameter heavy wall pipe with spacing of supports not exceeding 30-inches (See Appendix 4). The screed pipe should also be checked to make sure that it is in good condition.

The screeds should run the full length of the pour and extend beyond both ends a sufficient distance to permit the finishing equipment to clear the entire pour area. Screeds must be graded beyond the limits of the pour to assure proper grade at

the bulkheads and paving notches. Screed pipe splice sleeves should be in place to prevent cantilever action of the screed pipe. Screed pipe saddle adjustments and overhang adjustment nuts have been known to turn when subjected to vibration and should be wired or secured by other means in order to prevent rotation. All screed support elements should be checked during concrete placement. Nonuniform screed displacement or settlement can be caused by:

(1) lack of washers between adjusting nut and edge of deck panel;

(2) spaces between top plate and studs of overhang panel;

(3) spaces between overhang soffit and edge of deck panel.

The field notes and a level should be available during every deck pour in case there are any grade problems.

## 4-2.5 BULKHEADS

Section 51-1.11 of the Standard Specifications states that "Longitudinal construction joints in the bridge decks, if used, shall be located along the lane lines, unless otherwise shown on the plans or permitted by the Engineer." Past practice has been to try and place longitudinal bulkheads within a foot of a lane line.

To insure positive support, bulkheads and particularly screeds should be located over girder lines whenever possible. Check reinforcing steel splice details with regard to joint locations. Avoid the bend areas of truss bars as they are very

difficult to work around. If the bulkhead has to be installed on the lost deck-in a girder bay, the formwork may require "legging up from the soffit" to minimize deflection and settlement. Refer to the appropriate section of the Standard Plans and/or the Project Plans for allowable deck construction joint details!

Transverse bulkheads are placed at the inflection points of the structure (usually the 1/5 point) or in the deck compression areas. The location can vary somewhat on prestressed box girder bridges.' Reinforcing steel splice details with regard to joint location should be discussed before reinforcing steel fabrication and again during planning of deck concrete placement. Grading transverse bulkheads is basically the same as for paving notches (Refer to section 4-2.6).

Any transverse bulkhead should be regarded as a potential bump or problem area. All operations in the vicinity of a transverse bulkhead should be carefully checked. Grade control is particularly important. A good straightedge during the first bulkhead pour will not guarantee a good riding joint. The area needs to be reprofiled before the second bulkhead pour.

Make sure bulkhead forms are properly constructed and that bulkhead areas are properly cleaned prior to placing concrete. Premature stripping of transverse or longitudinal bulkhead forms should be prohibited due to spalling and the questionable cure that results. Simultaneous pouring on both sides of a joint (especially those having waterstop) should also be prohibited.

## 4-2.6 PAVING NOTCHES

Paving notches should be graded approximately 1/2" low in order to clear the finishing equipment. When the paving notch is not formed prior to the girder stem pour, be sure to leave the concrete for the girder stem or abutment diaphragm low enough to receive the paving notch forms. Make sure there is an adequate method for holding the paving notch to proper line and grade. Proper width, and straight and plumb joints are important when saw cutting for Type B jointseals. Check reinforcing steel clearances for possible interference with the joint seal saw cuts. The above also applies to sealed hinge joints as well as paving notches. Straight material must be available for a nailing strip used after the grade has been established by the finishing operation. The strip is nailed to the paving notch and is used as a guide for edging only. A 1/4" edger should be used without depressing the concrete. Other methods of finishing along the joint may be used if approved by the Engineer.

## 4-2.7 INSPECTION TOOLS

1. Twelve-foot straightedge.

   Used for checking localized grade deviations on screeds, bulkheads and armor plate, projecting surface planes of adjacent structural sections and checking surface of finished deck.

2. String Line.

Used to check "lost deck" forms from grade points, deck thickness and reinforcing steel clearances from screeds, alignment of finishing machine carriage rails and laying out lines. Always watch for sags when using a string line.

3. Eyeball.

The final and probably the mostimportant check for line and grade.

## 4-2.8 FINISHING MACHINES

Grading and inspection of bridge decks, prior to concrete placement, would not be complete without discussing the adjustment of finishing machines.

The Bidwell is the finishing machine most frequently used for bridge decks in California. Other machines that may be encountered are the Borges and Gomaco. The setup and adjustment of the Bidwell will be covered in the text. Bidwell finishing machine weights are listed in Appendix 4.

The greatest care should be taken in adjusting the finishing machine. Depending on the condition of the equipment, these adjustments can take anywhere from 3 to 8 hours and they must be done during daylight. If the machine appears to suffer from poor maintenance, you should be especially cautious and take the initiative to insist on chain repair kits, belts, even extra

bearings, sprockets, etc. Special attention should be applied to the condition of the machine. If the finishing machine breaks down, there is usually no alternative deck finishing method available on the job.

Subtle adjustments of the machine during a pour for a 0.02' change in grade often does more harm than good. Much has been said and written about how a finishing machine can be programmed for various subtle changes in grade. Generally, it is better to leave the machine at one setting for the entire deck pour.

Following is the recommended method for setting up and adjusting the Bidwell finishing machine:

BIDWELL - (Double or single Roller) Deck Finisher.

The following are steps to be used in checking this type finishing machine to insure it is in proper adjustment:

1. String line both trusses and adjust for crown or no crown conditions (make sure carriage is at center of truss and string line is not sagging.)
2. Move carriage to left or right side of deck adjacent to legs.
3. Place string line, which represents finished surface, across deck. String line should be parallel to trusses. Distance from truss rail to string on both sides of roller carriage should be equal.
4. Move machine over string line until ends of both rollers are over the string.

5. Check distance from roller surface to string - it should be the same for both rollers.

6. Lower or raise rollers to string via leg adjustment - both legs, fore and aft, should be moved an equal amount.

7. Fine tune legs (raise rear leg 1/8" if desired).

8. Repeat steps (4) to (7) by moving machine forward until back end of rollers are checked.

NOTE: (A) During the concrete pour, the skew of the rollers appears to be very critical. If a ridge is left behind the roller, it may be due to a change in the skew of the centerline of the rollers. This can be corrected by moving one side of the machine forward or back.

(B) At the beginning of the pour, the auger adjustment should be observed - often it is not set low enough. This will cause the rollers to load up, resulting in a ridge behind the machine.

Footnotes: 1. See Appendix 4 for "Bridge Deck Safety."